EVALUATION OF BACKGROUND WATER QUALITY STUDIES, HOMESTAKE MINING COMPANY NPL SITE, NEW MEXICO

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FOR THE MULTICULTURAL ALLIANCE FOR A SAFE ENVIRONMENT AND BLUEWATER VALLEY DOWNSTREAM ALLIANCE

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ALBUQUERQUE, NEW MEXICO

OUTLINE AND PRIMARY POINTS

- Standards/source information
- Review of Harte et al. 2019 report
- Evaluation of current background water quality
- Recommendations

Photo: BVDA Factsheet.

STANDARDS AND ADJUSTMENTS (MG/L UNLESS NOTED)

Parameter	NRC (GWPS)	NMWQCC (drinking water)	New Site Standards – Alluvial Aquifer	US EPA Safe Drinking Water Act
Uranium	0.04	0.030	0.160	0.03
Selenium	0.10	0.050	0.320	0.05
Molybdenum	0.03	1.0 (irrigation)	0.1	--
Vanadium	0.02	0.100 (irrigation)	0.02	--
Sulfate	--	600	1,500	250 (SMCL)
Chloride	--	--	250	250 (SMCL)
TDS	--	1,000	2,734	500 (SMCL)
Nitrate (as N)	--	10	12	10
Th-230 (pCi/L)	--	--	0.3	--
Ra-226+228 (pCi/L)	--	30	5	5

Sources: Weston Solutions, 2018; US EPA 2019; NMAC 20.6.23101

SOURCE INFORMATION

- Mill processed uranium by alkaline leaching and ammonia precipitation of yellow cake
- Tailings decant water contained 29,000 pCi/L gross alpha, 52 pCi/L Ra-226, 0.92 mg/L Se (Haufmann et al., 1975) – unlined impoundments
- Groundwater contamination first found in 1960 – U, Se, TDS, SO_4, NO_3, Mo; 220,320 gpd tailings liquid seeped from tailings impoundments to alluvium
- Homestake remediation began in 1976 – groundwater collection/monitoring system 1978
- Flushing of LTP – discontinued in 2012; ongoing flushing of alluvial and Chinle aquifer with SAG gw or RO/zeolite-treated water

Source: Weston Solutions, 2018.

MINE PROCESS AND TAILINGS LIQUIDS

Date/Source COC	April 1978 to Oct 1980 SMC Upland Alluvial Groundwater (Lee-1 and -2 Wells)	1981 Mine Discharge Ambrosia Lake Area	1981 Mine Discharge San Mateo Creek Area	1980-1982 Raw Mine Water Ambrosia Lake Area
Gross Alpha (pCi/L)	2.5 – 15.0	580	1,100	3,050
Ra-226 (pCi/L)	0.05 – 0.33	4.6	23	280
Molybdenum (mg/L)	0.005 – 0.01	0.79	0.32	1.19
Selenium (mg/L)	0.005 – 0.005	0.41	0.04	0.075
Uranium dissolved (mg/L)	0.005 – 0.010	2.4	0.08	3.82
Sulfate (mg/L)	5-20	837	205	715
Chloride (mg/L)	3 – 8	90	10	n/a
Total Dissolved Solids, TDS (mg/L)	125 -300	1,690	520	1,235
Arsenic (mg/L)	n/a	n/a	n/a	0.021

Notes: mg/L – milligrams per Liter; pCi/L – picocuries per Liter

Table 2.2. Hazardous substances and other constituents of concern in mine process liquids and tailings liquids

Constituent	Units	Concentration in process liquids	Concentration in tailings liquids
pH	s.u.	1.1	3.95
Aluminum	mg/L	1,380	722
Arsenic	mg/L	1.6	< 0.6
Cadmium	mg/L	0.3	0.14
Chloride	mg/L	1,540	2,300
Copper	mg/L	2.2	0.47
Iron	mg/L	2,990	1,400
Lead	mg/L	1.0	< 1.2
Lead-210	pCi/L	–	4.5
Manganese	mg/L	120	160
Molybdenum	mg/L	14	0.46
Nickel	mg/L	1.0	1
Radium-226+228	pCi/L	336	62
Selenium	mg/L	6	< 1.2
Sulfate	mg/L	34,600	16,000
Total dissolved solids (TDS)	mg/L	40,800	28,090
Thorium-230	pCi/L	–	11
Uranium	mg/L	11.2	8.4
Vanadium	mg/L	46	8.4
Zinc	mg/L	8.4	7.4

pCi/L = picocuries per liter; s.u. = standard units.

Sources: AVM Environmental Services and Applied Hydrology Associates, 2000; Maxim Technologies, 2001.

Source: Weston Solutions, 2016, Table 3-1.

Source: NM-ONRT, 2010

LTP WATER QUALITY (WELL T11 DISTINCTIONS, 2016 SNAPSHOT)

- Alkalinity
- Arsenic
- Barium ~
- Bromide ~
- Cadmium
- Calcium (low)
- Chloride ~
- Cobalt
- Copper
- Fluoride
- Iron (low)
- Molybdenum
- Nickel
- pH (high, 9.4)
- Sodium
- Specific conductance
- Sulfate
- Vanadium

Parameters with elevated concentrations in T11 relative to values in other alluvial wells; Cl and Fe concentrations were notably lower. Selenium not elevated compared to other alluvial wells; U not determined in T11, ST or CE7; ~ = only moderately elevated compared to other alluvial wells.

Data source: EPA, 2019; USGS data, Excel spreadsheet.

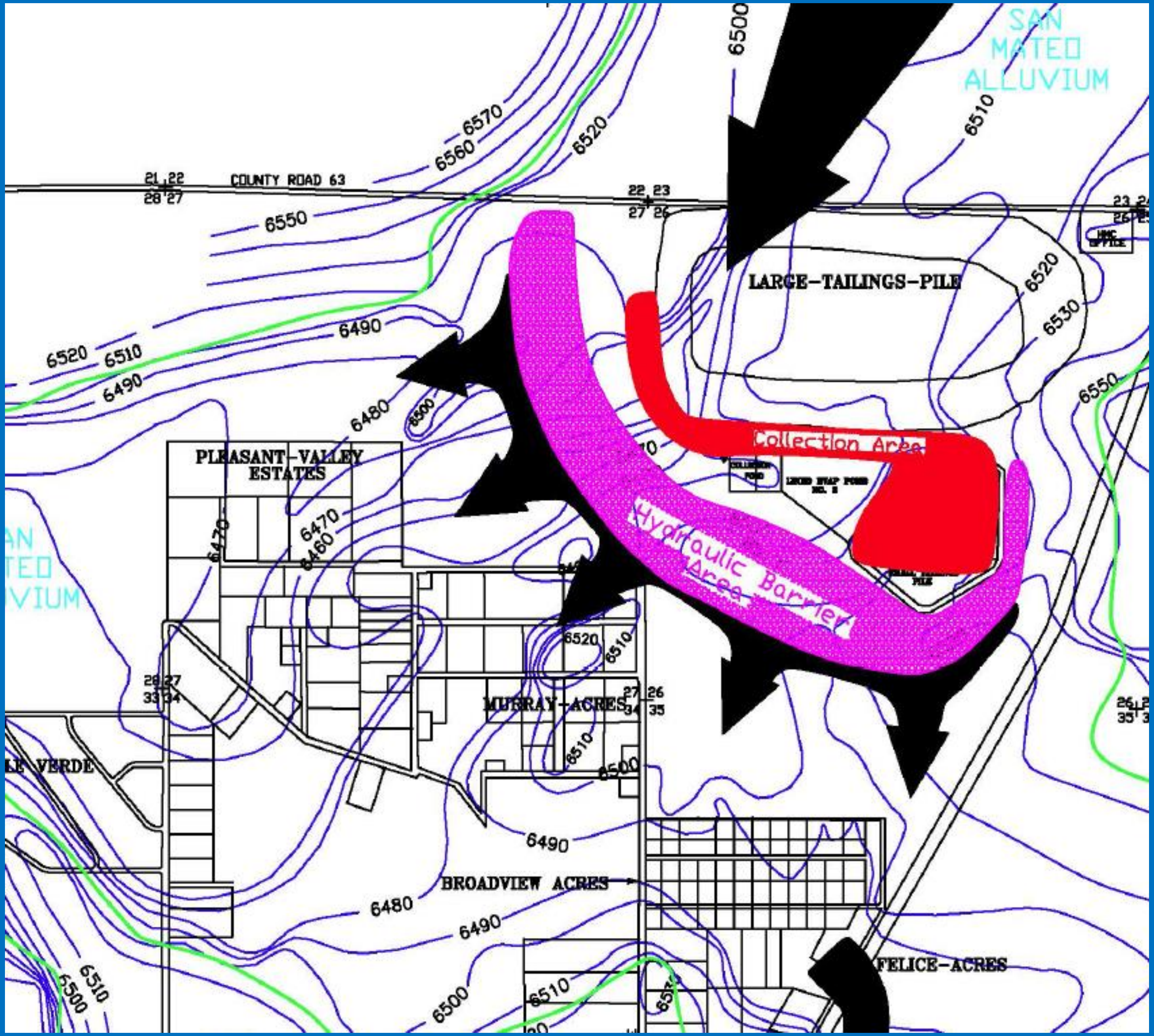
INJECTATE, OCTOBER 2016 (NOT RO PERMEATE)

- pH: 5.3
- SC: 729 μS/cm
- Total alkalinity: 31 mg/L as $CaCO_3$
- SO_4: 230 mg/L
- Cl: 48 mg/L
- NO_3+NO_2: 6.8 mg/L as N
- Total Ca: 47 mg/L
- Mg: 14 mg/L
- Na: 60 mg/L

- As: <1 μg/L
- Cd: <0.5 μg/L
- Total Cu: 35 μg/L
- Total Fe: 300 μg/L
- Pb: <0.5 mg/L
- Total Se: 11 μg/L
- U: 11 μg/L

Data source: EPA, 2019; USGS data, Excel spreadsheet.

ALLUVIAL FLOW AND HYDRAULIC BARRIER



Source: Homestake, 2015; Figure 2-20.

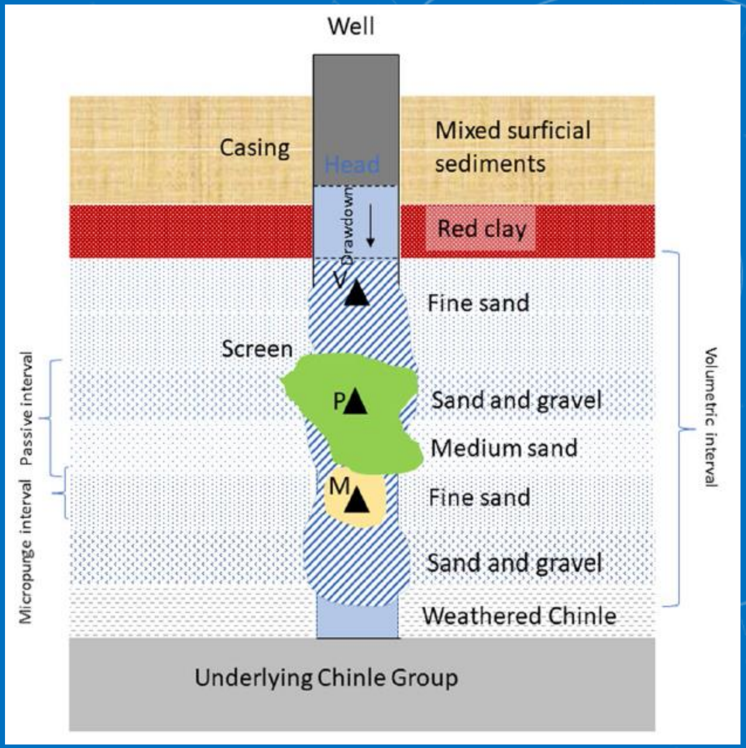
2016 USGS STUDY – HARTE ET AL. 2019

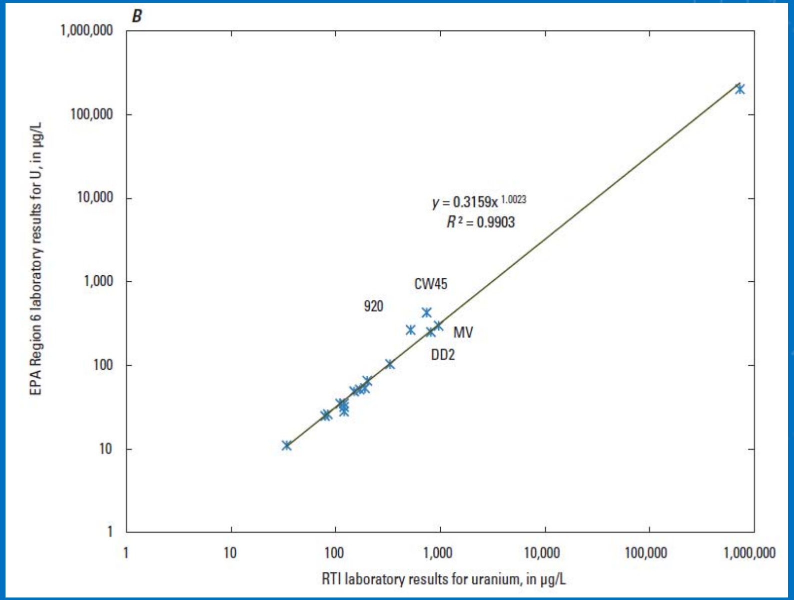
- Part of 2014 background water quality reassessment conducted at request of BVDA and MASE. EPA retained USGS to conduct 2016 field investigation at Homestake NPL site
- USGS goal: use variability in U concentrations in water and the formation to “gain insight” into natural vs anthropogenic sources. Researchy – different sampling methods; sampling/analytical issues.
- Examined only six wells: Q, DD2, DD, ND, T11, MV

Sources: Harte et al., 2019, Figure 1B.

2016 USGS STUDY (CONT.)

- Sampling and analytical issues (Harte et al., 2018 and 2019)
  - USGS (RTI) detection limits too high: U = 50 µg/L, Se = 10 µg/L
    - RTI detection/reporting limits: U = 2/5 µg/L, Se = 0.5/1 µg/L (ICP-MS)
  - Passive samplers didn't equilibrate; adsorption of U on passive sampler mesh
  - Blind sample: U concs 3.65x higher than expected
  - Two types of adjustments: sample (passive vs purge) and laboratory (RTI vs EPA). Sample: Increased concs by 3.55x for U (all samples) and 3.46x for Se (passive samplers). Lab: EPA results 1/3 RTI results, non-linear adjustment
- Discrete sampling advantages: finer control on changes with depth and information on inflow to screen





Sources: Harte et al., 2019, Figure 2; Harte et al., 2018, Figure 4B.

USGS STUDY: MAIN FINDINGS

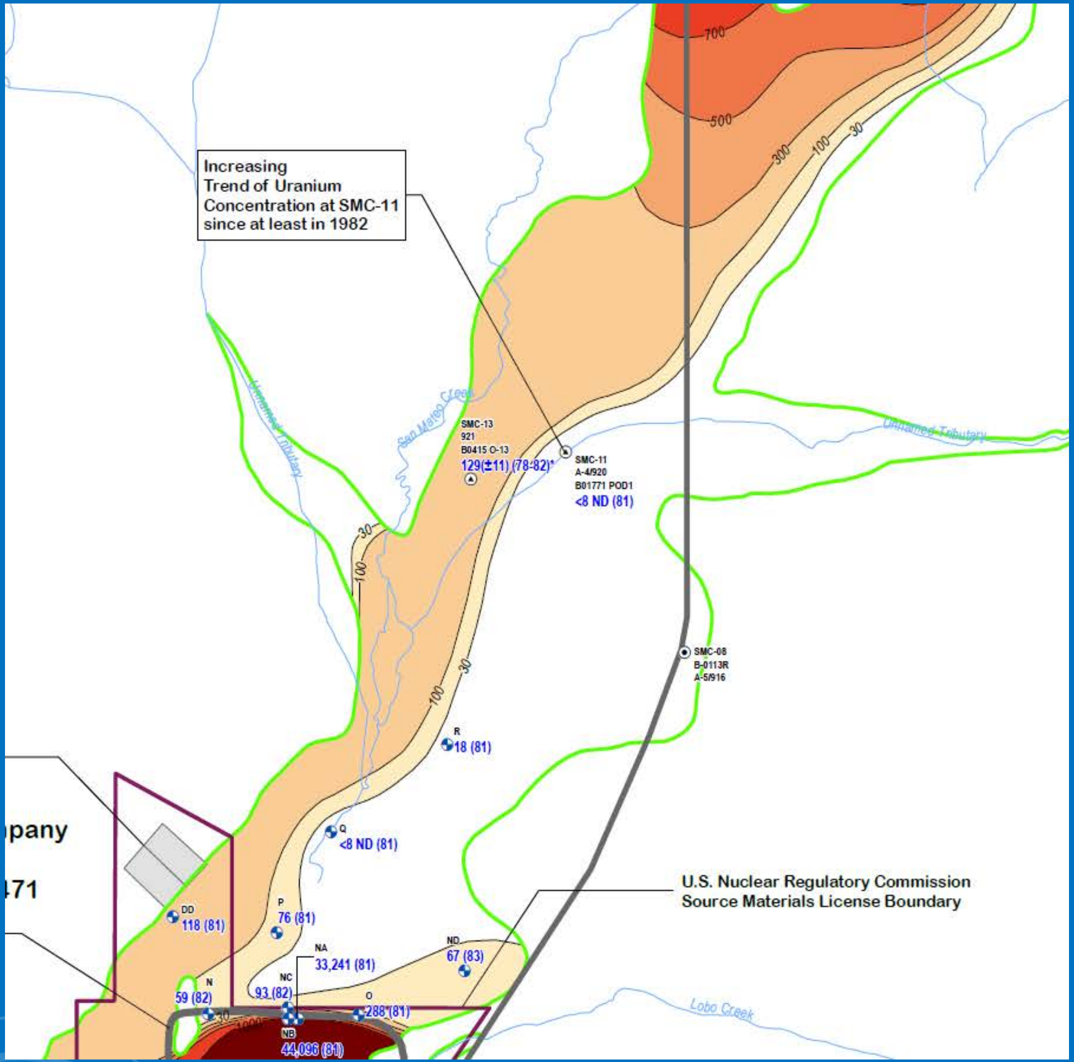
- LTP-proximal wells used for background could be downgradient of LTP (mounding)
- Well Q affected by regional milling operations (upstream; high R^2 U and Se)
- High U in vadose zone in DD, DD2, T11
- DD, DD2, ND: upwelling of Chinle groundwater
- Higher [U] and isotope ratios and lower [Se] could reflect lack of mining influence or mixing with Chinle or fault water

GROUNDWATER MONITORING WELLS

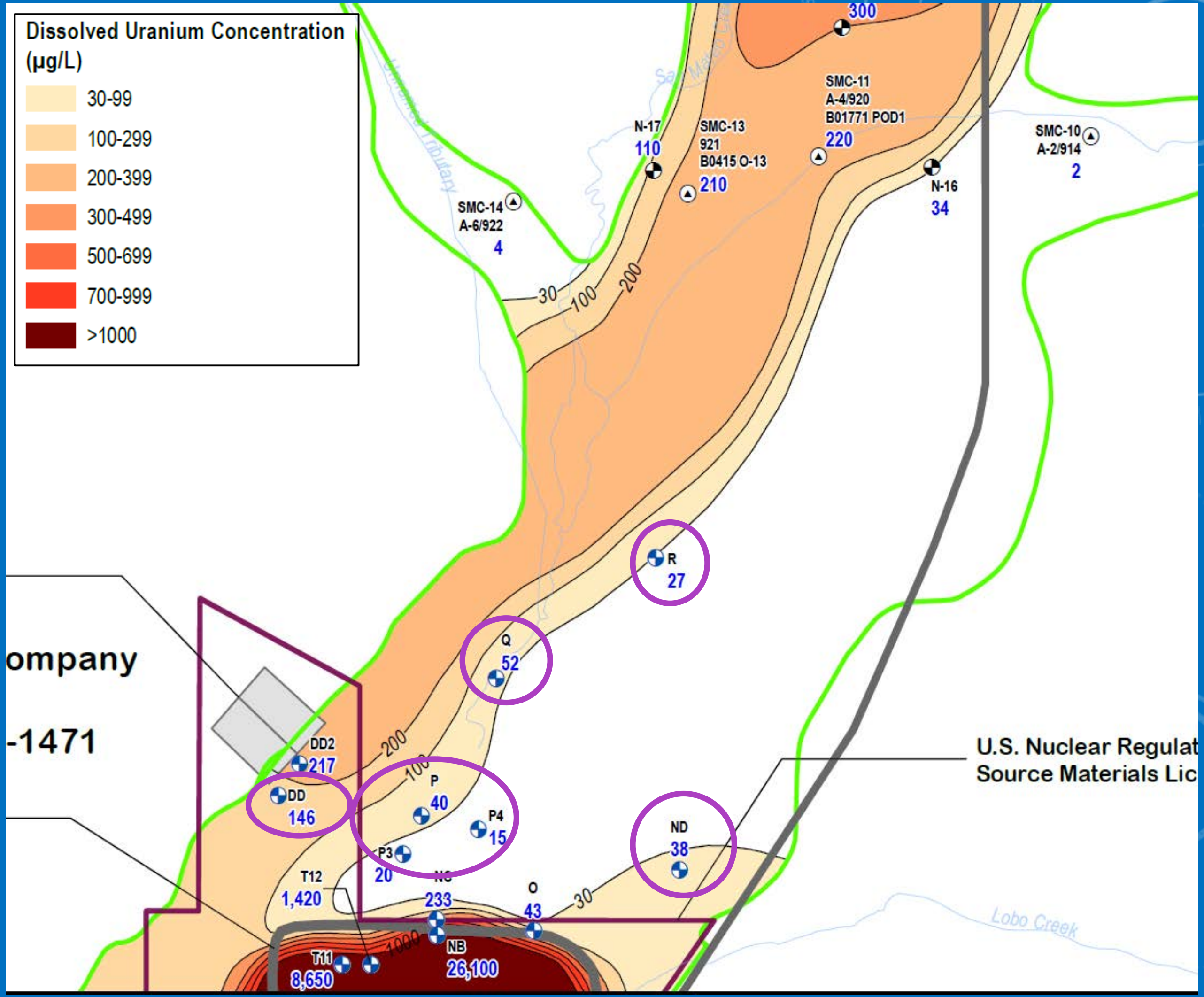
Wells used in background evaluation:
DD, ND, P, P1, P2, P3, P4, Q, R.
Blue = upper Chinle
Green = middle Chinle

Source: Arcadis white paper

BACKGROUND WELLS IN U PLUME



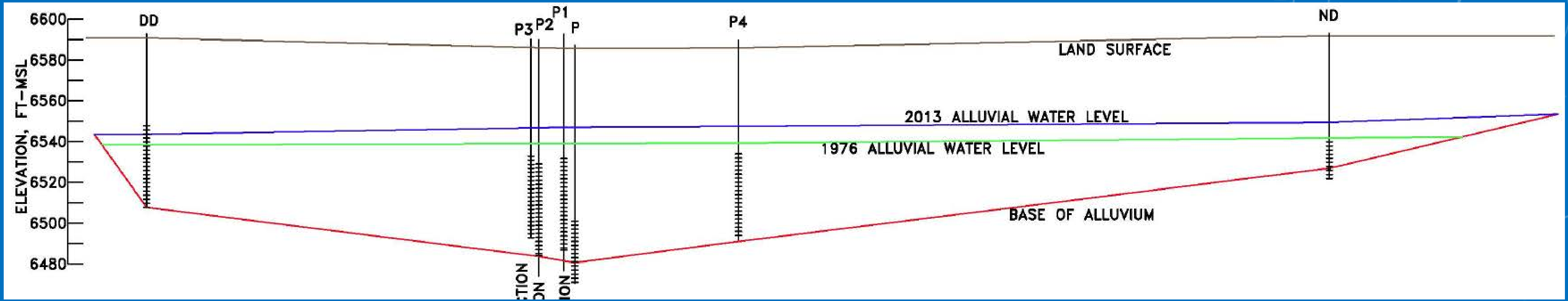
Late '70s – early '80s

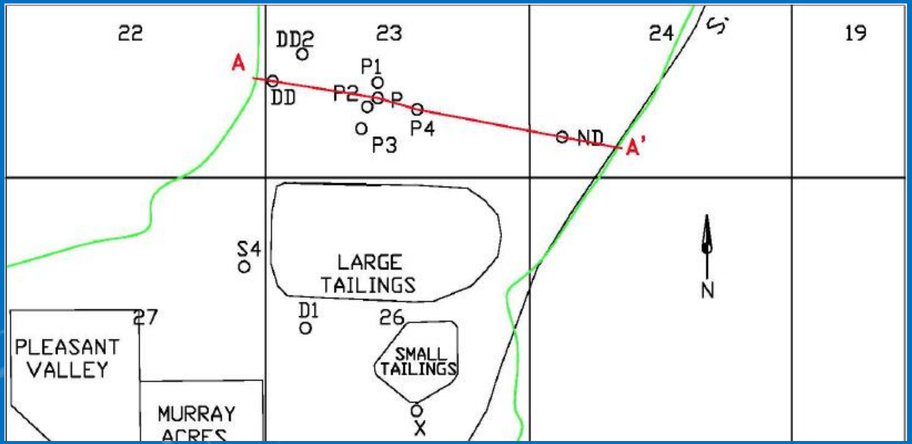


2015

Source: Weston Solutions, 2018, Figures A4-12 and -13

BACKGROUND WELLS – MIXED WITH CHINLE



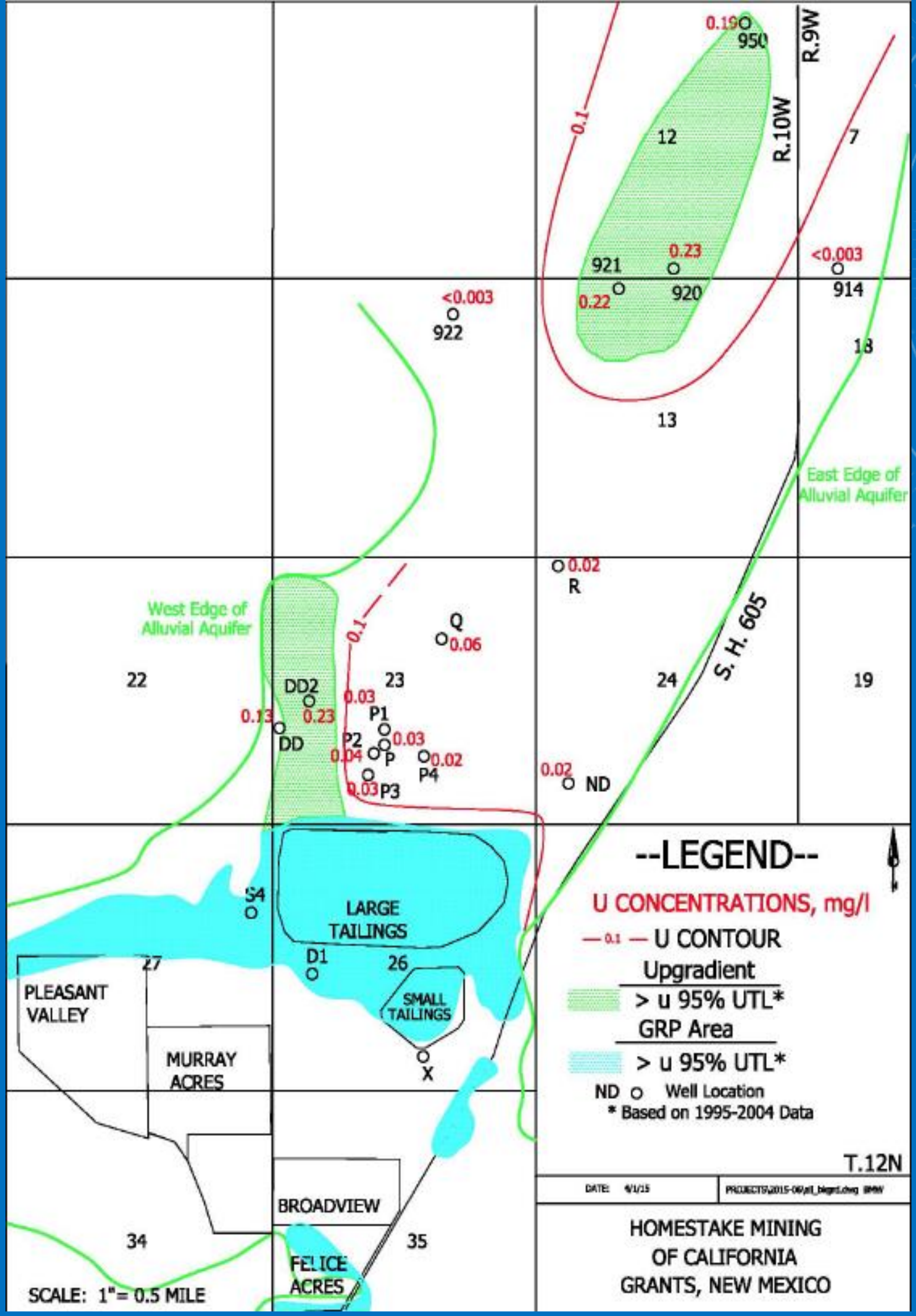


- Wells P and ND are partially screened in Upper Chinle – not alluvial wells
- Harte et al.: DD, ND: upwelling of Chinle groundwater (flowmeter)
- Wells P1, P2, P3 are essentially one well with ~ same screened intervals

Sources: Homestake, 2015, Figure 2-6.

ALLUVIAL WELLS

- No alluvial background wells used show U conc >0.13 mg/L
- No monitoring wells between two green-highlighted areas; U concs similar
- More monitoring wells needed

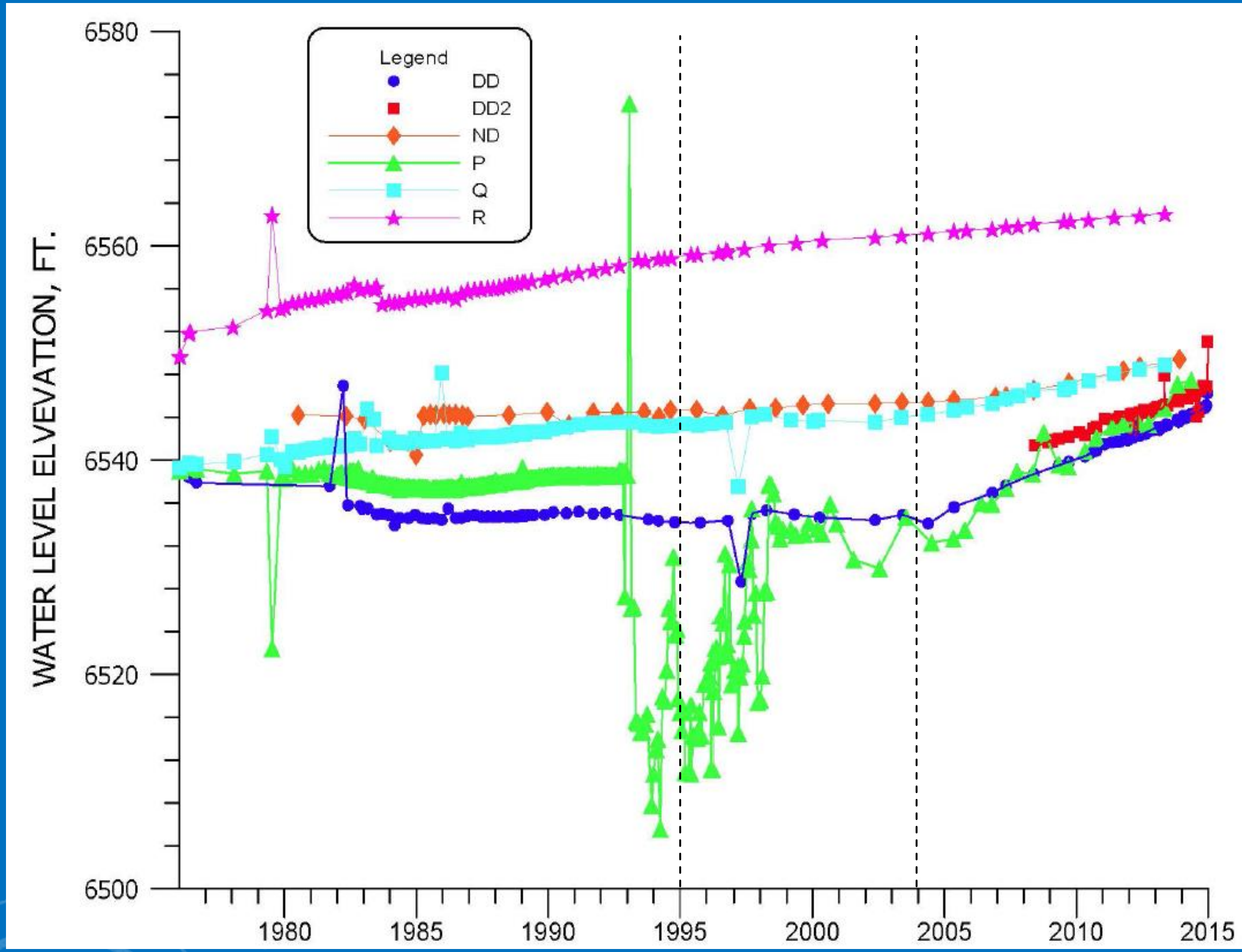


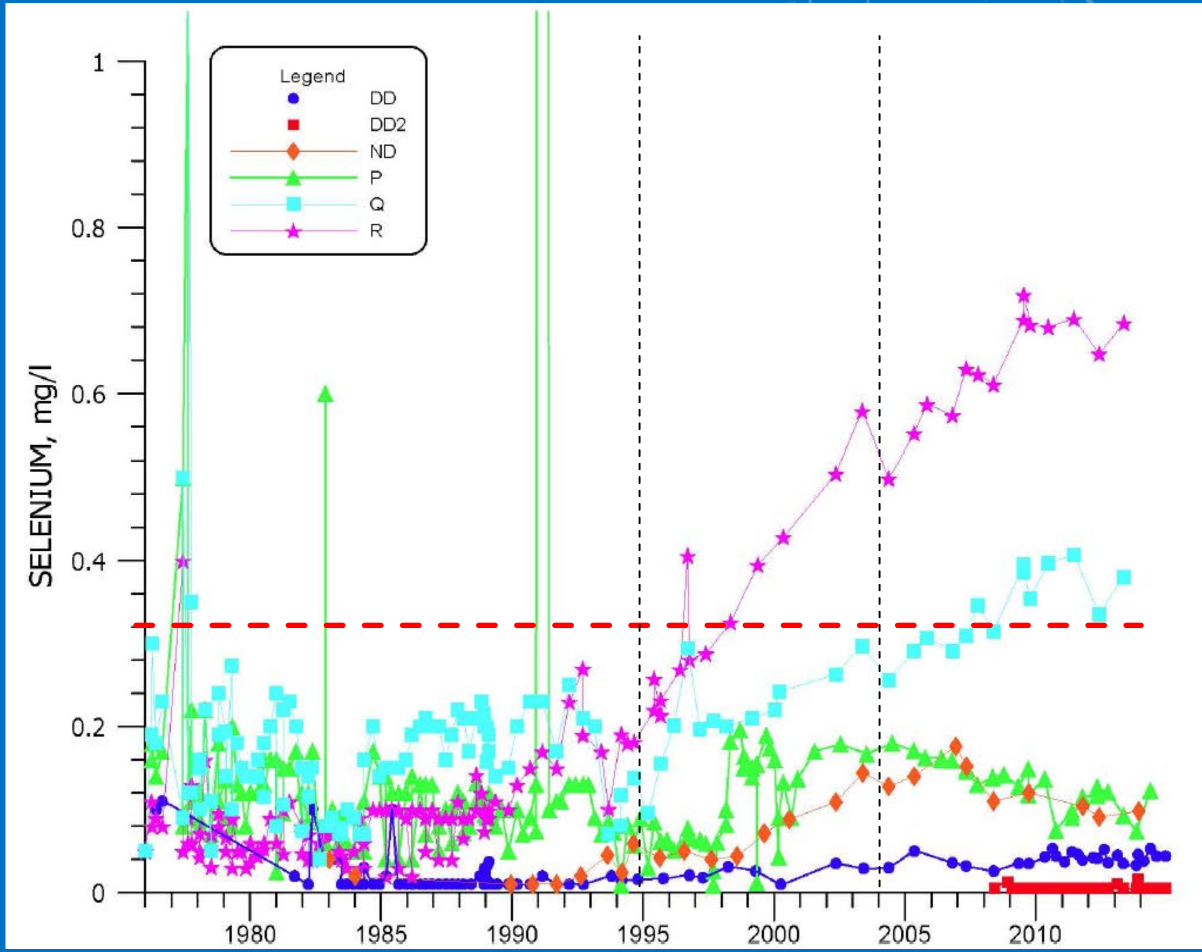
Source: Homestake, 2015, Figure 2-11.

IMPORTANT MISSING DATA AND INFORMATION

- …there are large data gaps that need to be filled to fully characterize the ground water and the extent of impacts by mine discharge water recharge. There are areas larger than a square mile with no monitoring wells…Additional investigatory work is needed to fill these data gaps and refine the conceptual site ground-water model… (Weston Solutions, 2018, p. ES-6, ES-7)

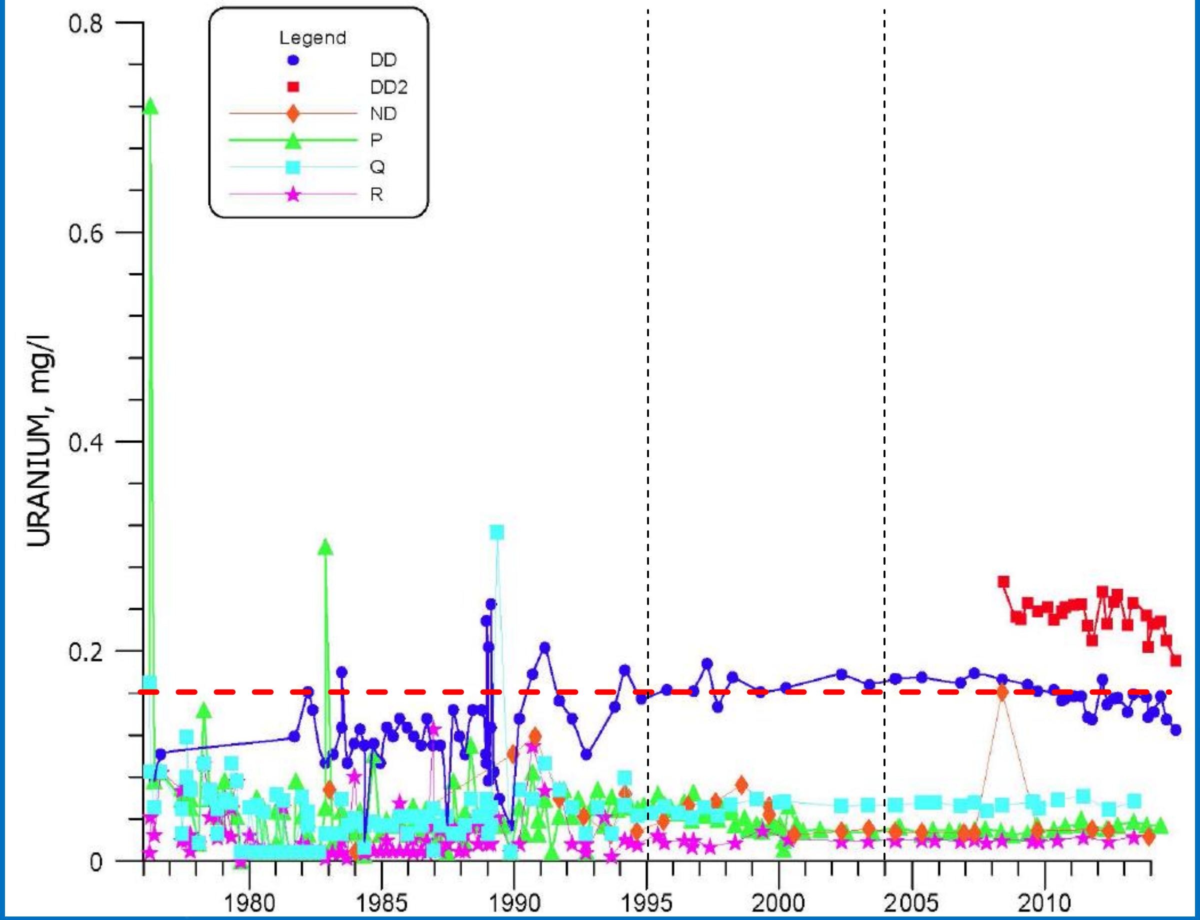
WELLS WITH INCREASING OR HIGHLY VARIABLE WATER LEVELS AND INCREASING CONCENTRATIONS SHOULD NOT BE USED

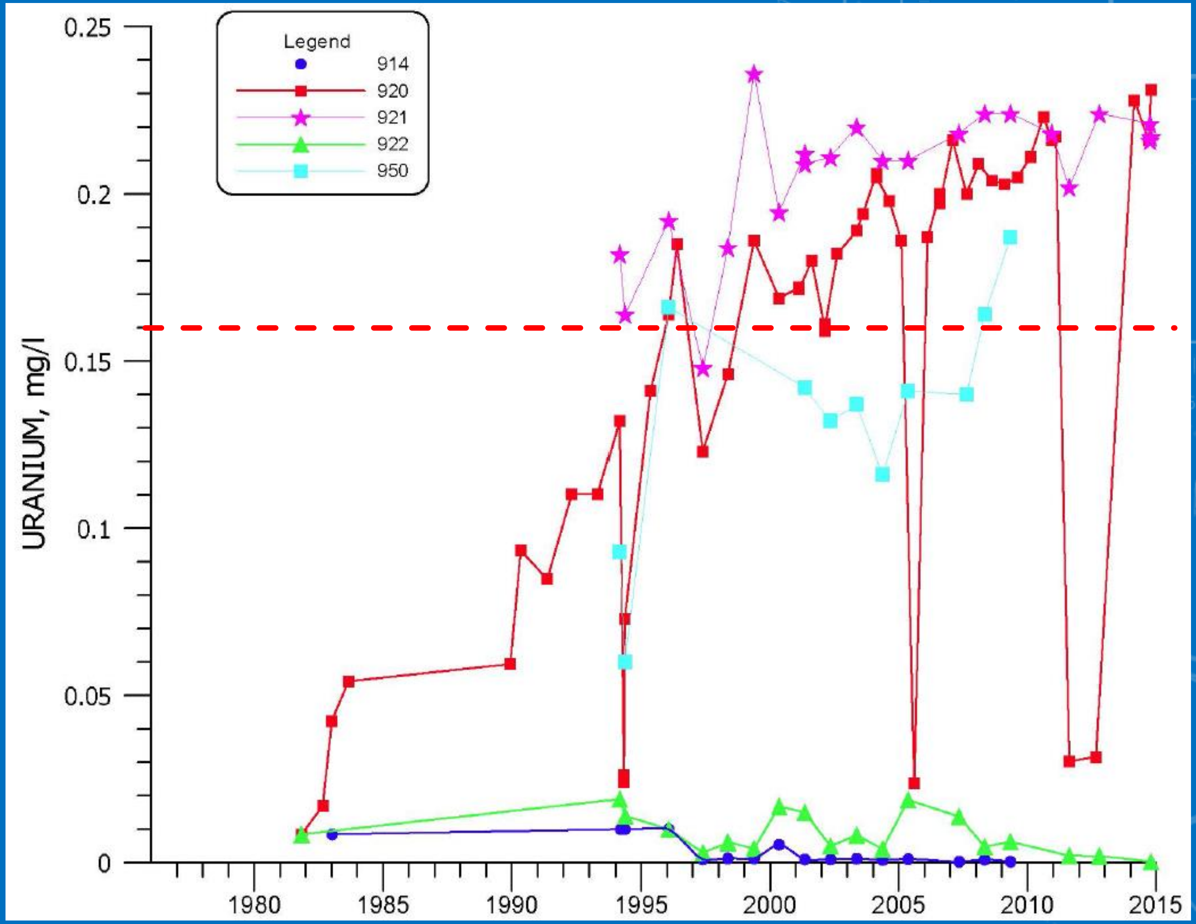




Sources: Homestake, 2015, Figure 2-7, 2-9.

URANIUM CONCENTRATIONS: BACKGROUND/ALLUVIAL WELLS





Source: Homestake, 2015, Figure 2-12.

CONTRADICTORY STATEMENTS

- The alluvial aquifer in the southern part of the floodplain, just north of the Homestake NPL Site, appears to now contain a large portion of mine discharge water from the recharge event(s). (Weston Solutions, 2018, p. ES-7; refers to recharge of mine-influenced water)
- …uranium concentrations used in the background analyses completed for the site in 2004 **have not been affected by up-gradient mining, and the background levels for uranium are considered representative of local natural conditions**… (Homestake, 2015, p. 1-2; emphasis in original)
  - Attributed to greater retardation of U relative to Se
- **Selenium** concentrations in two (wells Q and R) of the nine near up-gradient background wells show impacts from the up-gradient area mining and milling activity beginning in the mid 1990’s, but there were no impacts in any of the background wells prior to this time. (Homestake, 2015, p. 1-3). [same statement for nitrate]
- High uranium in the unsaturated zone shows that uranium is present in unaffected alluvial sedimentary material (Arcadis, 2019)
  - See following slide
  - Why “naturally” high in only one area? (DD, DD2) – also high in T11

ONLY ONE SAMPLE WITH HIGH U IN VADOSE ZONE

Samples with detected uranium

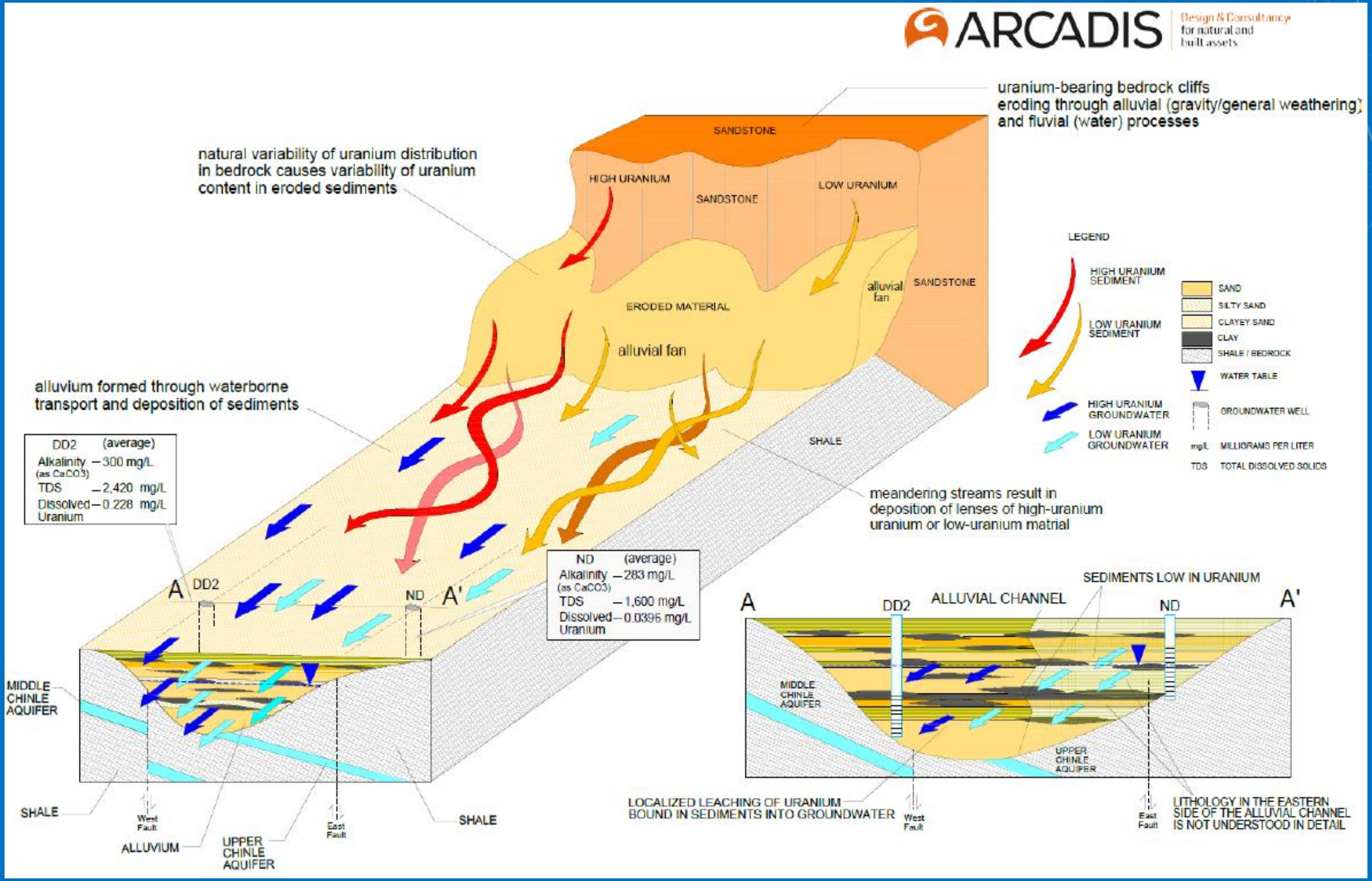
ARCADIS Design & Consultancy for natural and built assets

Sample ID	Alluvium zone	Total uranium concentration (mg/kg)	Alkaline SPLP leached uranium (mg/L)	Field-logged lithology	ACZ Particle Size Analysis Lithology	DCM analysis
DD2-BK-11-12-012218	unsaturated	10	0.179	CLAY	Clay	Yes
DD2-BK-71-72-012318	saturated	5	0.0305	Gravely SAND with silt	Sand	Yes
DD2-BK-51-52-012318	saturated	2	0.0086	Silty SAND	—	Yes
DD2-BK-60-61-012618	saturated	2	0.0086	CLAY with trace sand	—	Yes
DD2-BK-25-26-012218	unsaturated	1	0.0477	SAND with trace silt	Sand	Yes
DD2-BK-56-57-012318	saturated	1	0.0079	Silty SAND	—	No
DD2-BK-65-66-012318	saturated	1	0.0080	Sandy SILT	—	No
DD2-BK-67-68-012618	saturated	1	0.0180	CLAY	—	No
DD-BK-36-37-012518	unsaturated	1	0.0127	CLAY	Clay	Yes
DD-BK-58-59-012618	saturated	1	0.0032	CLAY	—	Yes
DD-BK-9-10-012518	unsaturated	1	0.0022	CLAY with trace sand	Clay	Yes

19 samples (excluding duplicate) were analyzed by ELI, only those with detectable total uranium concentrations are shown in the table

Source: Arcadis, 2019.

ARCADIS CONCEPTUAL MODEL



Source: Arcadis, 2019.

CONCLUSIONS AND RECOMMENDATIONS

- Site is complicated: upstream and mounding influence, water quality variability
- Many monitoring gaps – more wells needed
- Many issues with selected alluvial background wells: influence from LTP and upstream sources, mixing with Chinle, few unique locations
- Need to broaden search for true background wells
    - One well is controlling U value: DD; dissimilar hydrogeologic setting, lack of wells between it and far upgradient wells, potential mixing with Chinle
    - Do not use wells with increasing concentrations (eliminates Q, R) or increasing water levels (eliminates R, P)
    - Do not use wells in identified plumes or with mixed water sources (eliminates P, Q, R, DD, ND)

REFERENCES

- Arcadis U.S., Inc. 2018. Evaluation of Water Quality in Regard to Site Background Standards at the Grants Reclamation Project. September. Prepared for: Homestake Mining Company of California. 1206 pp.
- Harte PT, Blake JM, Thomas J, Becher K. 2019. Identifying natural and anthropogenic variability of uranium at the well scale, Homestake Superfund site, near Milan, New Mexico, USA. Environ Earth Sci 78:95.
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- Weston Solutions. 2018. Phase 2 ground-water investigation report for the San Mateo Creek Basin legacy uranium mines site, Cibola and McKinley Counties, New Mexico. Prepared for: US EPA Region 6. October 1.
- Weston Solutions. 2016. Phase 1 – Groundwater investigation report for San Mateo Creek Basin Uranium Legacy Site, Ciboa and McKinley Counties, New Mexico. Prepared for: US EPA Region 6. 30 August.

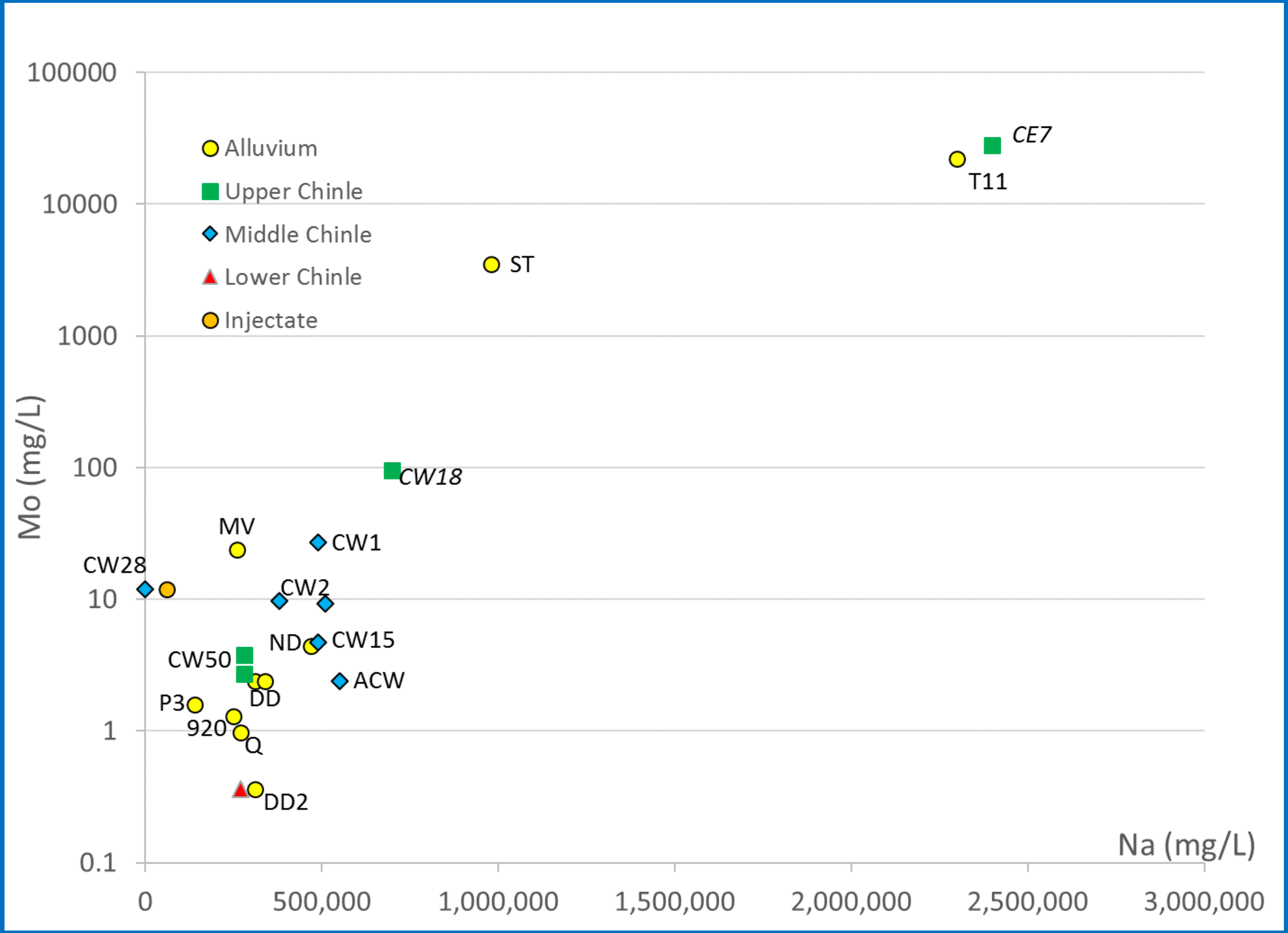
EXTRA SLIDES

REGULATORY ISSUES

- 1978: Placed under Title II UMTRCA (active), NM regulates
    - Alternate concentration limits (ACLs) can be approved is: as low as reasonably achievable considering practicable corrective actions, AND protective of human health and the environment
- 1983: EPA placed mill site on NPL; Homestake-EPA settlement agreement (municipal water connections, pay 10 yrs ‘85-’95)
- 1986: regulatory responsibility for mill returned to NRC
- 1993: EPA-NRC MOU. NRC lead for tailings reclamation; EPA oversight on CERCLA requirements outside tailings area
- 1989, 2001, 2006, 2008, 2014: Groundwater standards set or reassessed [2014 reassessment requested by BVDA/MASE)
- 2007: Homestake-NMED MOA (municipal water for newer or opt-out residents)

Source: EPA Phase 2 Ground-Water Investigation Report; Arcadis White Paper

MOLYBDENUM VS SODIUM, 2016



Data source: EPA, 2019.